THE ECOLOGY OF *ARABIS FECUNDA*:

LONG-TERM MONITORING AND SPOTTED KNAPWEED REMOVAL STUDIES.

1989 PROGRESS REPORT

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INTRODUCTION

In order to adequately protect populations of an organism, it is necessary to understand its life history and population dynamics (Massey and Whitson 1980, Sutter 1986, Palmer 1987). In addition, many rare species are threatened by interactions with non-native species that have been introduced into their habitat (Drake 1988). It is important to understand the nature of these interactions in order to protect populations of rare species from extinction.

Sapphire rockcress (Arabis fecunda Rollins) is a rosette-forming perennial in the Mustard Family (Brassicaceae). This recently described species (Rollins 1984) is endemic to highly calcareous, azonal soils in the foothills of the Sapphire Range in Ravalli County and in the Pioneer Range in Beaverhead and Silver Bow counties, Montana (Lesica 1985, Schassberger 1988). Arabis fecunda occurs on eroding slopes with low vascular plant density. Often these sites have a relatively high cover of cryptogamic soil crust. In Ravalli County, populations of Arabis fecunda are thought to be threatened by livestock grazing and encroachment by an aggressive exotic weed, spotted knapweed (Centaurea maculosa) (Lesica 1985).

This paper is a progress report on two studies being conducted on populations of Arabis fecunda in Ravalli County. The studies and their purposes are:

Study 1. Long-term monitoring of Arabis fecunda populations. Purpose: Determine important life history attributes, and determine trends in overall recruitment and mortality.

Study 2. Spotted knapweed removal study. Purpose: Determine the effects of spotted knapweed competition on the reproductive performance and survivorship of Arabis fecunda.

METHODS

Study Areas

We conducted our studies at two sites in Ravalli County, Montana: Charleys Gulch and Birch Creek. The Charleys Gulch site is on a steep, eroding, southwest-facing slope along the gulch at an elevation of ca. 5,000 ft. (T6N R19W S29, NW1/4). The Birch Creek site is on a steep, eroding, southeast-facing slope above the creek at an elevation of ca. 4,700 ft. (T7N R19W S16, NW1/4). More complete descriptions of the study sites can be found in Lesica (1985) and Schassberger (1988).

Long-term Monitoring Study

In May, 1987, we established permanent belt transects of 12 adjacent m^2 plots at each site following the methods outlined in Lesica (1987). Individual Arabis fecunda plants were mapped and recorded using the following system:

S - Seedling
R - indicates the number of rosettes per plant
I - indicates the total number of inflorescences (stems) per plant
F - indicates the total number of fruits produced by the plant

Thus, a plant with two rosettes, three stems and a total of nine fruits would be recorded as R1-I3-F9. Seedlings were recognized by their small size (< 15 mm diameter). Many single or multiple rosette plants may also be first-year plants. In addition, we noted the presence of recently disturbed soil and evidence of livestock trampling. We did not record seedling-size plants at the Birch Creek site in 1987. In 1989 we collected 50 randomly selected fruits from different individual at Charleys Gulch, and 25 fruits at Birch Creek. Each fruit was hand-dissected, and the number of seeds in each was recorded. We read the transects on May 19-20, 1987 and 1988 and May 24-25, 1989. Population density and fecundity data are presented in Table 1.

Spotted Knapweed Removal Study

In May, 1987, we established two permanent belt transects consisting of 10 adjacent m^2 plots at each of the study sites following the methods of Lesica (1987). Transects were placed in areas with relatively heavy spotted knapweed infestations. Individual Arabis fecunda plants were mapped and recorded as in the long-term monitoring study. For each transect, we removed the spotted knapweed from five randomly selected plots by carefully cutting the plants below the root crown with a sharp knife. Spotted knapweed was removed from plots 2,4,5,8, and 9 at Birch Creek and from plots 1,4,5,8, and 9 at Charleys Gulch. We did not record seedlings at the Birch Creek site in 1987. Ocular estimates of percent canopy cover of spotted knapweed were made for treatment and control plots each year. We read the transects on May 19-20, 1987 and 1988 and May 24-25, 1989. Data on percent canopy cover of spotted knapweed are presented in Table 2; performance parameters for A. fecunda are shown in Table 3.

Data Analysis

Population growth rate was calculated for each long-term monitoring study site in 1988 and 1989 by taking the increase in individuals over the previous year and dividing by the number of

individuals present in the plot the previous year. Negative growth rates reflect a decreasing population size.

Discussion

I. Long-term monitoring studies

1. The severe drought that occurred in 1988 appears to have influenced total fruit production at both Charleys Gulch and Birch Creek (Table 1). During that year, the percentages of fruiting plants reached the lowest recorded levels. However, over the three study years, at both sites, there has been an increase in the fecundity (# fruits/fruiting plant) of the reproductive individuals.

2. The slight negative population growth rate at the Charleys Gulch site may be due, in part, to the impacts of cattle trampling, which was very evident at this site in both 1988 and 1989.

II. Spotted knapweed removal studies

1. Yearly removal of spotted knapweed from randomly selected plots in the study transects has resulted in a decrease (but not eradication) in the mean percent canopy cover of spotted knapweed in those plots, at both Charleys Gulch and Birch Creek (Table 2).

2. At Charleys Gulch, an increase in plant densities occurred in the spotted knapweed removal plots over the three-year study period (Table 3). At Birch Creek, a drastic increase was detected in 1988, followed by a decrease in 1989 (Table 4). In the control plots, densities remained fairly constant at Charleys Gulch, and decreased slightly in 1989 at Birch Creek. These data suggest that reduction of interspecific competition from spotted knapweed may allow increased establishment of A. fecunda plants. The population growth statistics reflect these changes.

3. The fecundity parameters were apparently heavily influenced by the drastic climatic fluctuations during the three-year study period. To fully assess the potential influence of spotted knapweed competition on fecundity, additional transect readings over several more years are needed.

Table 1. Population density and fecundity data for Arabis fecunda in long-term monitoring transects, 1987-1988.

		Birch Creek	Charleys Gulch
Density (plants/m^2)	1987	4.8	6.5
	1988	4.6	6.0
	1989	4.9	5.5
Population growth	1988	0.14	-0.08
	1989	0.05	-0.08
# plants fruiting	1987	20	33
	1988	7	11
	1989	32	24
% plants fruiting	1987	35%	42%
	1988	11%	15%
	1989	47%	36%
# fruits per fruiting plant	1987	3.8	5.1
	1988	14.0	8.8
	1989	22.0	15.8
# fruits per inflorescence	1987	2.2	2.1
	1988	5.2	3.0
	1989	6.8	3.9
% plants with more than one rosette	1987	9%	27%
	1988	8%	38%
	1989	9%	30%
% one-rosette plants with fruit	1987	29%	37%
	1988	12%	22%
	1989	45%	35%
% multi-rosette plants with fruit	1987	83%	57%
	1988	0%	4%
	1989	67%	40%

Table 2. Percent canopy cover of spotted knapweed (Centaurea maculosa) in removal transects in 1987 (before spotted knapweed removal), 1988 and 1989. An asterisk (*) indicates plots from which spotted knapweed was removed; remaining plots are controls.

Charleys Gulch #2

Year	* 1	2	3	* 4	* 5	6	7	* 8	* 9	10	Control Mean	Removal Mean
1987	20	25	20	25	28	23	20	23	30	25	23	25
1988	5	20	28	15	18	30	25	23	18	35	28	16
1989	2	25	33	5	10	28	30	8	5	30	29	6

Birch Creek #2

Year	1	* 2	3	* 4	* 5	6	7	* 8	* 9	10	Control Mean	Removal Mean
1987	30	35	35	30	33	38	28	23	23	28	32	29
1988	30	20	30	30	20	30	15	30	30	20	25	26
1989	28	10	40	15	15	23	15	5	5	20	25	10

Table 3. Performance parameters for *Arabis fecunda* in spotted knapweed removal (n=5) and control (n=5) plots at Charleys Gulch (mean=SD).

	1987		1988		1989	
	Removal	Control	Removal	Control	Removal	Control
Density (plants/plot)	12.8+3.9	14.2+3.6	14.4+3.3	14.0+4.2	19.4+5.8	13.4+3.7
Fruiting plants/plot	5.8+2.7	4.6+2.6	0.4+0.5	0.4+0.9	6.4+4.2	5.4+2.5
% plants fruiting	39.3+13.0	32.5+17.6	2.4+3.2	4.0+8.9	30.6+16.6	39.9+13.0
New plants	---	---	4.2+2.6	3.0+2.9	7.0+3.2	2.6+1.3
Dead plants	---	---	2.6+3.6	3.2+2.0	2.0+2.0	3.2+1.5
Population growth	---	---	0.15	-0.02	0.41	-0.08
# fruits/plot	26.8+17.0	18.6+6.7	4.6+6.8	3.4+7.6	104.8+61.9	82.0+38.1
# inflorescences/plot	12.2+6.7	8.4+3.8	1.0+1.4	1.0+2.2	27.6+17.7	21.2+9.7
Fruits/inflorescence	2.2+0.3	2.4+0.5	4.5+0.7	3.4+0.0	3.9+0.4	3.8+0.3
Inflorescence/fruiting plant	2.1+0.5	2.1+1.1	2.5+0.7	2.5+0.0	4.4+1.1	4.4+2.2

Table 4. Performance parameters for Arabis fecunda in spotted knapweed removal (n=5) and control (n=5) plots at Birch Creek (mean+SD).

	1987		1988		1989	
	Removal	Control	Removal	Control	Removal	Control
Density (plants/plot)	16.0+3.9	21.2+6.5	58.0+59.2	24.0+3.7	32.6+12.9	17.2+10.3
Fruiting plants/plot	8.8+2.9	8.0+4.5	1.2+1.3	1.4+2.1	11.2+5.3	5.4+4.7
% plants fruiting	54.7+12.1	35.7+12.3	4.6+6.2	5.5+7.9	33.7+9.7	36.2+17.9
New plants	---	---	50.4+60.3	13.6+8.6	16.8+6.3	7.8+5.4
Dead plants	---	---	11.4+5.2	10.8+5.8	42.2+50.4	14.6+5.9
Population growth	---	---	2.67	0.27	-0.12	-0.28
# fruits/plot	55.6+26.4	39.2+16.9	18.2+18.6	8.0+10.7	348+169	139+168
# inflorescences/plot	22.2+6.6	18.8+9.2	3.6+4.6	1.8+2.9	41.6+18.4	22.0+23.2
Fruits/inflorescence	2.4+0.6	2.4+1.1	6.5+3.1	5.9+2.2	8.6+2.9	5.7+1.9
Inflorescence/fruiting plant	2.2+0.6	2.6+1.0	2.7+0.9	1.1+0.2	3.8+0.6	3.5+1.5

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Appendix B

DEMOGRAPHIC MONITORING OF *ARABIS FECUNDA* IN THE PIONEER RANGE

1989 ESTABLISHMENT REPORT

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INTRODUCTION

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Sapphire rockcress (Arabis fecunda Rollins) is a rosette-forming perennial in the Mustard Family (Brassicaceae). This recently described species (Rollins 1984) is endemic to highly calcareous, azonal soils in the foothills of the Sapphire Range in Ravalli County, and in the Pioneer Range in Beaverhead and Silver Bow counties, Montana (Lesica 1985, Schassberger 1988). Arabis fecunda generally occurs on steep, often eroding slopes with low vascular plant density. In Ravalli County, populations of A. fecunda are thought to be threatened by livestock grazing and encroachment by an aggressive exotic weed, spotted knapweed (Centaurea maculosa) (Lesica 1985, Schassberger 1988). In Silver Bow and Beaverhead counties, populations may be threatened by mining activity and livestock grazing.

This report documents the establishment of demographic monitoring transects for Arabis fecunda at two sites in the Pioneer Range, on Beaverhead National Forest lands.

STUDY SITES

I. Lime Gulch

Location: Five miles west of Interstate Highway 15, on the north side of Birch Creek Road, approximately 1/4 mile up Lime Gulch from the road; T5S R10W Sec 14; ca. 6,200 ft elevation.

a. South Transect

Location: East-facing slope on the west side of the gulch, ca. 20 m up from the bottom. 98 degrees from the start pin to the summit of Limestone Mountain; 204 degrees to the summit of the grassy mountain south of Birch Creek Road. The start pin is next to an old juniper stump.

Line bearing: 21 degrees

Slope: 16 degrees

Aspect: 165 degrees

Instructions: Read transect south to north.

b. North Transect

Location: West-facing slope on the east side of the gulch, ca. 5 m above the bottom. 209 degrees from start pin to the summit of the bald hill with patches of trees; 17 degrees to the base of the Douglas fir snag near the bottom of the gulch.

Line bearing: 178 degrees

Slope: 22 degrees

Aspect: 274 degrees

Instructions: Read transect north to south.

II. Canyon Creek

Location: Approximately 12.5 miles west of Melrose on the Canyon Creek Road, at the corner of the road overlooking the kilns; T2S 10W Sec 8; 7,200 ft elevation.

a. West Transect

Location: Moderate, south-facing slope. 162 degrees from the start pin to the southwest-most kiln; 227 degrees to the junction of the guard station road.

Line bearing: 110 degrees

Slope: 31 degrees

Aspect: 205 degrees

Instructions: Read transect west to east.

b. East Transect

Location: Moderate, south-facing slope. 178 degrees from the start pin to southwest-most kiln; 48 degrees to wooden platform.

Line bearing: 96 degrees

Slope: 30 degrees

Aspect: 180 degrees

Instructions: Read transect west to east.

METHODS

On June 15 (Lime Gulch) and 16 (Canyon Creek), we established two permanent belt transects of 12 adjacent m^2 plots at each site, following the methods outlined in Lesica (1987). The start and end points of each transect were marked by a section of reinforcing bar driven into the ground and painted orange. Individual A. fecunda plants were mapped and recorded using the following system:

S - Seedling (rosette less than 15 mm diameter)
R - indicates the number of rosettes (> 15 mm diameter) per plant
I - indicates the total number of inflorescences (stems) per plant
F - indicates the total number of fruits produced by the plant

Thus, a plant with two rosettes, three stems and a total of nine fruits would be recorded as R1-I3-F9. In cases where plants had not finished blooming, two flowers or flower buds were recorded as one fruit. Since a first year plant can bloom and set fruit (Lesica and Shelly, personal observation), the above system describes size rather than age classes.

At each site, we located 25 randomly-chosen plants outside of the transects, and picked one fruit from each. We dissected each fruit, and recorded the number of viable-appearing seeds in each.

Many of the plants at Canyon Creek were still flowering when we read the transects; thus we recommend that this transect be read in late June or early July.

RESULTS AND DISCUSSION

A summary of the data collected in 1989 is presented in Table 1. All plants were mapped and scored to size class within each of the four transects. Fecundity was much greater in the Canyon Creek population than the Lime Gulch population. Also, the Canyon Creek population had a higher percentage of plants with more than one rosette. The Lime Gulch population is ca. 1,000 ft lower in elevation and in the rain shadow of the Pioneer Mountains. The differences in fecundity could be an artifact of

sampling on consecutive days at sites which have very different microclimates, i.e., the phenology of the two populations may not be the same. The reason(s) for the difference in rosette number is unknown.

Table 1. Population density and fecundity data for Arabis fecunda in long-term monitoring transects, Beaverhead National Forest, 1989.

	Canyon Creek	Lime Gulch
Density (plants/m^2)	15.8	15.4
# plants fruiting	95	6
% plants fruiting	25.1%	1.6%
# fruits per fruiting plant	10.8	3.2
# fruits per inflorescence	5.5	1.7
% plants with more than one rosette	20.3%	12.2%
% one-rosette plants with fruit	23.8%	0.9%
% multi-rosette plants with fruit	29.9%	6.7%
Seeds per fruit	34.2+10.5	31.1+5.6

LITERATURE CITED

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